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INDUSTRIAL ECONOMICS

Some years ago, it was highly proper —or popular—to look upon an economist as a theorist who was trying (unsuccessfully) to correlate actual industrial happenings with what he considered to be irrevocable economic laws. If this economist dared attempt to use statistics—"figures"—in his theorizing, he was doubly damned as both a fool and (if he disagreed with popular belief) a scoundrel.

This reaction, fortunately, is not encountered by modern economists, except in a few instances. Economists and statisticians have been "right" sufficiently often to inspire respect if not absolute belief, and accurate statistical information is becoming more and more readily available, so that future predictions by qualified economists are likely to increase in correctness.

Concurrent with the present flood of statistical information and credence in economic studies has come the need for qualified groups to prepare specific analyses as the need arises. Such an analysis may be concerned with the most desirable location of a new industry, or it may deal with a survey of local potentialities for the establishment of a number of new industries, but in any case it requires the gathering and interpretation of "facts and figures" by qualified people.

The South is now in the midst of a tremendous industrial expansion, based upon undoubtedly great advantages in raw materials, manpower, and—always important—financial opportunity. Such expansion, if it is to be sound and permanent, must also be based upon adequate economic information, interpreted in the light of all the existing circumstances.

It is highly encouraging, then, to note the existence of state planning commissions, industrial groups, and other organizations whose function it is to gather and disseminate industrial information, and it is also interesting to note the activities of such groups as the Station's Industrial Economic Research Staff and the Industrial Economics Division of the Commerce Department of the Tennessee Valley Authority. Both of these are mentioned or described in articles in this issue, and they and similar groups are to be commended for their service to this region and to the nation—and referred to for advice when the occasion arises. Information, economic or otherwise, is only of value when it is used.

INDUSTRIAL USES OF SPECTROGRAPHIC ANALYSIS

By WILLIAM M. SPICER*

Accurate knowledge of the composition of a substance is the bulwark of any enterprise that depends upon raw materials. For this reason, accurate, rapid methods for the acquisition of this needed information are of the greatest significance. This article discusses for the layman the importance, wide usefulness, and many advantages of the spectrographic method of analysis.

From the simple observation that sunlight passing through a glass prism is broken into the colors of the rainbow to the development and use of an apparatus that saves a single industrial concern over a million dollars a year—that is the history of spectrographic analysis. Oddly enough, although this history covers a period of almost three hundred years, industrial spectroscopy is hardly more than a decade old—yet today, if a hundred spectrographs in key industrial plants were to be removed, the effect would be almost as disastrous as that of a major strike.

What is this instrument, this spectrograph, that is now so important to our industrial machine? How does it work, and what can it do? In particular, what can it do better than can be done in other ways?

These questions will be answered later in some detail, but a brief description of the instrument would seem in order here. It has long been known that each element, when heated to incandescence, emits light which

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Figure 1. The spectrograph in operation. The arc in which the sample is being excited may be seen at the left, while the excitation unit is shown at the right. This unit furnishes the electric power to excite the sample; its complexity is due to the need for controlled excitation conditions that can be varied from arc to spark.

is distributed over the spectral range in a different manner and to a different degree from that of any of the other elements. A spectrograph, according to definition, is "an instrument for analyzing light into its component wave lengths." In this instrument, therefore, the material to be studied is heated to incandescence in an electric arc, and its light is then broken into its component wave lengths for study.

ADVANTAGES

One of the traditional problems of chemistry is that of analysis; i.e., the determination of the composition of materials. It is in this field—analytical chemistry—that the spectrograph finds one of its most important uses, some of its advantages being:

1. The spectrograph is reliable. Should two chemists disagree as to the composition of some material on the basis of regular chemical analyses, they can subject the material to spectrographic analysis to settle the matter once and for all.

Actually, many of the elements were discovered by use of the spectrograph. One of the first of these, helium (from the Greek word meaning "sun"), was proved to be present on the sun twenty-seven years before it was discovered on the earth. Between 1860 and 1870, four other elements were discovered spectrographically, each of them deriving its name from the Greek word for the color of its predominant spectral line—rubidium (red), cesium (blue), thallium (green), and indium (indigo). It is interesting to note that, soon after the Franco-Prussian War, a French spectrographer who discovered a new element proved himself more of a patriot than a scientist by naming the new element gallium for ancient Gaul. As was to be expected, the next element discovered in Germany was named germanium! We Americans, not to be outdone, named element number 61, which was isolated at the University of Illinois, illinium, and element number 96, produced in connection with the atomic bomb project, americium.

One of the last elements identified spectrographically was the man-made element plutonium, of atomic bomb fame. This work with plutonium, which was at first produced in only infinitesimal quantity, illustrates a second advantage of spectrographic analysis:

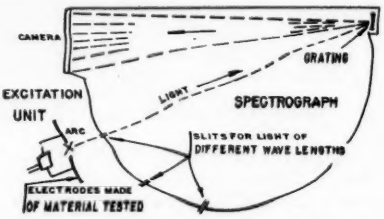

Figure 2. Diagram of the spectrograph. Light characteristic of the material being analyzed (from which the electrodes of the excitation unit are made) is emitted by the arc, focused on the diffraction grating, and broken into its component wave lengths, whose intensities and variations are photographed for further study.

2. The spectrograph requires only a very small sample. No more than a millionth of a pound, a mere speck, is sufficient. This is not so surprising, however, when it is considered that even this small sample contains over a million billion atoms.

3. The spectrographic method is very sensitive. The spectrograph can detect traces beyond the limits of chemical methods; with most metals, it will detect one part in ten million. This is comparable to detecting one particular person in the total population of the states of Georgia, Florida, and North and South Carolina.

4. A single photograph is in general sufficient for the identification of all the elements present in a sample. A few nonmetals like sulfur and chlorine are exceptions, but these are easily detected in other ways. No laborious separation into "groups" (required for regular methods of analysis) is necessary. This leads to perhaps the most important advantage of the spectrographic method:

5. The spectrographic method is rapid. Even the qualitative analysis of a material may require days by ordinary chemical methods, especially if unfamiliar elements are present. With the spectrograph, such an analysis can be made in a matter of minutes, and elements whose presence is unexpected give no more trouble than those which were anticipated.

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PATENTS AND INDUSTRY

By B. H. WEIL*

Many engineers and industrialists, although trained and experienced in their respective fields, have developed the attitude that patents and patent dealings are to be shunned like the plague. This feeling is perhaps understandable in view of the complexities of patent law, the sheer ponderosity of the patent structure, and the fact that few colleges offer courses in patent technology. However, it is vitally important that such sentiments be dispelled, so that the inventive individual and the progressive company may reap the proper harvest of their efforts with due protection of law and, also, avoid complications arising from unintentional infringement of existing unexpired patents. This article is the first of a series which will discuss some of the factors of patent technology with which each engineer and industrialist should be familiar.

In this age of industrial progress and activity, patents are objects which have come in for a good deal of attention and abuse, both verbal and actual. They have been cited as the bulwark of oppressive monopolies, praised as the protectors of industrial progress and the instigators of further developments, and bemoaned as being unreasonably complex and expensive. As in all arguments, there are two or more sides to each question, but the fact remains that patents are with us to stay, so long as the principle of private ownership is our guiding precept. Therefore, they should be carefully considered whenever an industrial operation is to be undertaken.

That inventive efforts should reward their originators only by the accompanying glow of achievement was not the purpose or intent of the founders of our country. Article I, Section 8 of the Constitution of the United States provides that "the Congress shall have power * * * to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

So complex have become the patent laws and interpretations which have since evolved, however, that this basic theorem of patent law has largely been forgotten by the average individual. In brief, it states that the purpose of the patent system is the promotion of science and the useful (i.e., industrial) arts, not by governmental grants but by permitting the individual whose genius or inspiration has conceived the advance to have *exclusive* use of his invention for a limited period, after which it becomes public property. This is neither an altruistic nor a one-sided affair; the inventor gains the right to seek legal action as protection for his invention, but he dedicates its eventual use to the public, and his written description, published as a patent, increases the public storehouse of knowledge.

PATENT FALLACIES

Before discussing what a patent is and what details must be considered prior to its acquisition, it might be helpful to consider what a patent is not. First of all, despite the prima facie statement that a patent endows its owner with the exclusive right to "make, use, and sell" the object or process invented, a patent may do no such thing. It does offer a potential legal barrier to others who would like to apply the new concept to their operations without permission, but it affords no assurance to the patentee, in case he proceeds to apply it, that his manufacturing will not infringe on the existing patent rights of others.

Consider, for example, the inventor who has discovered a mechanical brake which, because of certain features, seems to work more efficiently than those available. His search of the prior art indicates that the features in question have not been patented; his application for a patent meets with success; and he then proceeds to put his brake into manufacture for a number of uses. If he has actually been scientific in his

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approach, he is probably aware of somewhat similar patents, in addition to patents on other features of the brake which, being already patented, he has not claimed, or on which, having claimed, he was refused patent protection. However if he is not aware of these patents or chooses to ignore them, his operations may be brought to a jarring halt by a suit for patent infringement. In other words, the action of the Patent Office in granting a patent gives the inventor the exclusive right to "make, use, and sell" the unique features which he has invented, but it does not endow him with the legal authority to manufacture a complete article if that article also contains features covered by other unexpired patents.

When this situation exists, the inventor must (1) obtain a license to use the existing unexpired patents, (2) buy them outright, (3) reach an agreement whereby the holder of the basic patents gives permission to use them in exchange for the right to use the new invention in his own operations, (4) sell his invention, or (5) "sit on his invention," refusing others the right to use it without being able to use it himself. This limitation in the patent grant is frequently—usually—encountered, for few inventions are as basic as the telephone, electric light, or nylon.

Another popular belief, closely allied to this misconception of patent dominance, is that a patent is somehow a legal document which may be applied per se to prevent others from using the invention. This, of course, is far from true; all that the ownership of a patent provides is the right to take legal action in the courts to effect this. In such legal actions, the defendant will of course try to prove that the patent is not infringed by his operations and/or that it is invalid for any of several reasons, so that the patent owner must feel certain of the validity and strength of his patents if they are to be of any real value to him—a sound reason for following proper patent procedures.

Even if the invention is basic, is so new that its use will not infringe on unexpired patents (the use of no invention infringes on expired patents since these, by fundamental patent law, are public property), the inventor is given no assurance by the patent grant that his patent will make him wealthy or that it will become a commercial success.

For the latter, commercial exploitation is far more important, usually, than intrinsic merit, although merit is a definite necessity. To succeed commercially, an invention must: (1) warrant replacement of existing articles of a similar nature, or create a demand because of its outstanding features, (2) warrant replacement of dies and machines used in the manufacture of the existing article by new (and perhaps expensive) machines needed for the manufacture of the new article; (3) not cost substantially more to manufacture than similar articles; (4) not infringe on existing unexpired patents; and (5) be sufficiently protected by patents to prevent others from producing equivalent articles.

Some of these "musts" may occasionally be disregarded, but only rarely; in fact, it would seem that "modern advertising and high pressure salesmanship have in many cases relegated merit to a secondary place. From the promoter's point of view, such things as 'sales appeal,' 'eye appeal,' 'talking points,' etc. * * * are far more important than the efficiency of operation of the device sold."[1]

As regards quick wealth, it must suffice to note that over 2,400,000 patents have so far been issued in the United States and that patents are now being issued at a rate of approximately 1,000 per week. Men are not becoming wealthy at any such rate. It has been estimated that probably no more than half of the patents issued repay the costs involved in their acquisition. While a patent is not issued unless it appears useful as well as original, many patents fail to meet the test of commercial practicability or are difficult to exploit for any of several reasons. Also, while United States patents are legally presumed to be valid until proved otherwise, many are indefensible for reasons of legal carelessness in keeping the research records, failure to apply for a patent at the proper time, uncontrolled public use, etc., and operations whose economic security is based on exclusive rights may find themselves suddenly without patent protection.

[1]Anon., Patent Background for Engineers, Allis-Chalmers Manufacturing Company, Milwaukee, 1941.

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NEW POTTERY PLANT FROM CERAMIC ENGINEERING RESEARCH

By CHARLES F. WYSONG* *and* JULIAN H. HARRIS**

The establishment of the Ceramic Engineering Department at Georgia Tech was authorized by the State Legislature in 1923, in order to promote the manufacture of more finished products from the abundance of high-grade raw materials that are found in the state. Through its research and by the training of young engineers, the department has attempted to justify the responsibilities entrusted to it by the founders and has, in addition, been instrumental in bringing more than a dozen ceramic enterprises to the state. One of these is described in this article.

The American pottery industry has always been largely concentrated in Ohio, Pennsylvania, New York, and New Jersey, chiefly because of a freak of immigration. The early pottery makers who migrated to this country settled in these areas and, pottery making being a skilled handicraft, it mattered little that sources of raw materials were not near at hand—kaolin, for example, was even imported from England for many years. Raw material costs of a few dollars per ton mattered little in the production of pottery valued at hundreds of dollars per ton.

Recently, California has made a bid for dominance in this field with the establishment of about 800 separate shops, often one- or two-man affairs. This latter trend, however, appears to have nearly run its course, and, as conditions return to normal, the economic disadvantages of inefficiency and higher freight rates will undoubtedly take their inevitable heavy toll of such expansions.

Georgia, on the other hand, possesses particular advantages as a ceramic center, these advantages arising, first of all, from the availability of high grade raw materials in strategic localities. "About three-fourths of the known deposits and mining activity in kaolin are in Georgia, located on a line extending from Augusta to Macon to Columbus"[1]. With the opening of feldspar and flint deposits near Monticello, early in 1947, at least 75-85% of the ingredients for chinaware, pottery, and porcelain will be readily available in the vicinities of Atlanta and Macon. Research on clay particle sizes being conducted under the direction of Dr. Lane Mitchell, Head of the Ceramic Engineering Department, indicates that additional processing of fine-grain clays might easily furnish the remaining 15-25% of the ingredients needed for an all-Georgia body.

NEW INDUSTRY MADE POSSIBLE BY RESEARCH

The first modern, commercial-scale pottery plant to be established and financed within the state has recently been completed, and it may be of interest to note that its erection was made possible by the cooperation of Georgia Tech.

Upon returning from the services, the authors investigated the possibilities of es-

Figure 1. Pouring of the mold. A previously poured casting is shown at right.

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** *Associate Professor of Architecture and Ceramic Engineering.*

[1]Hosmer, J. B., et al. *Ceramic Whiteware Prospectus.* Georgia School of Technology, State Engineering Experiment Station, Bulletin No. 8, 1945.

Figure 2. Pouring the ceramic "slip" into a mold which has been prepared in a manner similar to that previously shown.

tablishing a pottery plant in Georgia for producing much-needed items for Southeastern distribution.

Following a decision to erect a plant, the organization was completed by the addition of Mr. Stanley B. Ashley, President of Ashley Associates, and a project was initiated between the new company and the Georgia Tech Engineering Experiment Station "to carry on pilot plant whiteware operations; to develop technical data, designs, and marketing data; and to provide a small scale training program."

During the summer of 1946, while the school facilities were not crowded, the project was carried out in the Ceramics Department. Raw materials and bodies were investigated, and data pertinent to manufacture were gathered. A large amount of work was done on stained bodies by a technique which differs from that used on typical ware in that the color is carried uniformly throughout the entire ware instead of appearing only in the usual glaze veneer. A clear glaze is applied over the stained body, and the true color is developed during firing. Uniformity of color, reduction of glaze defects, and continuity of color throughout the body are looked upon as advantages which more than offset the additional cost of color ingredients and the extra attention needed to prevent contamination of batches.

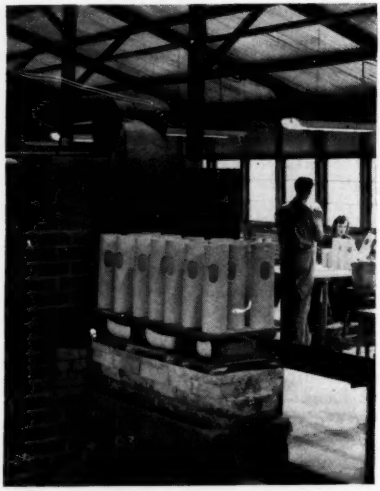

Figure 4. Bisque ware emerging from the kiln.

During the summer period, about 25 designs were developed. Firings were made to

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Figure 3. Dressing and sponging the green ware, which has been removed from the plaster mold when the desired wall thickness has formed through adsorption of water by the plaster mold. Extra slip is poured off.

INDUSTRIAL STATISTICAL ANALYSIS

By JOSEPH B. HOSMER*

Sound industrial enterprises depend for their success on a combination of enlightened market evaluation and efficient business practices. Both of these require standards of comparison for true self-measurement, however, and modern statistics—properly interpreted—are capable of providing the needed information. This article describes a comparison technique for the evaluation of industrial operations and costs.

The use of statistics as a guide to executive judgment has become increasingly important in the past fifteen years, concurrent with the gradual disappearance of credence in the theory that "all statisticians are liars." One factor in this change has been the very large increase in the basic information available, not only in kind but also in extent.

For example, the Census of Manufactures, which is taken in every odd-numbered year (except during the war period), provides the "raw material" (basic economic data) which manufacturers can use to compare the economics of an individual operation with the United States average or state averages in that field or even in a completely different field. Such comparisons are not at once evident, however, since the census figures given are unrelated totals; to remedy this, the Industrial Economic Research Staff here at Georgia Tech has devised a comparison technique which will be described in this article.

The last Census of Manufactures covered the business year 1939, so that this, with additions made in 1940, is the latest of its type available. The next one is expected for 1947, and its findings are being awaited with much interest. The 1939 data are so comprehensive, however, that they are still worth considering, despite the tremendous industrial changes of the past few years, and for this reason a brief description of the classifications employed and the type of data assembled in each Census of Manufactures should be of interest here. All factory types of operations are combined into 446 types, for each of which the following basic dollar figures are published: Plant Salaries, Cost of Materials, Value of Products, and Value Added.

Other figures usually included are Salaried Officers (salaries of officers), Distribution Salaries, Construction Salaries, and detailed breakdowns of the amounts for Fuel and Purchased Electric Energy — items which are included in the Cost of Materials. In addition, the Number of Establishments and the number of persons receiving each of the salary and wage figures are shown.

United States totals, regional totals, and state totals are given for every item listed under each of the 446 industries, except that state figures are combined under "other states" where there are less than three plants in a state or where a single firm dominates the total for a state.

COMPARISONS DIFFICULT

Great difficulty is usually experienced in making direct comparison between state totals because of differences in the magnitude of the figures; such comparisons between industry types are even more confusing. Since these direct comparisons are of considerable importance, however, the previously mentioned technique, developed here at the Engineering Experiment Station, has proved very useful; it consists in reducing the dollar figures for all other reported items to multiples of the figures for total plant expenditure for wages and salaries. This is accomplished by dividing the sum of wages and salaries into each of the other reported totals and so placing the decimal that the resulting figures can be stated thus: "the Value Added in Manufacture per $100 of wages and salaries is $....." This value will always be more than $100, because the Value Added as calculated by the Bureau of the Census includes wages and plant salaries, the items whose sum is used as divisor. Thus, by subtracting $100 (representing these wages and salaries) from the Value

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Added, one gets a residue which represents the margin which must cover such items as management expense, rent (or use of property), interest paid, and profit. Comparisons made possible by this new figure, called Gross Margin, are often the most useful permitted by this technique.

TABLE DESCRIBED

For example, Table I, taken from a special Station report which deals with the paper industry in Georgia, shows this data for "Paperboard Containers and Boxes, Not Elsewhere Classified." The paperboard container industry is one which is widely distributed, the 1,338 establishments being located in 42 states (for 33 of which state figures are available). States shown in Table I are all in the South except two, New York and Ohio, which were selected for comparison.

The indented lines in Table I measure the figures on the preceding lines in terms of their ratio to the all-important figure for payrolls. The basic theory which is illustrated by Table I is that these plant payrolls, from the individual and community viewpoint, are the first economic justification for manufacturing, just as the earning of a net profit is the first economic necessity for the manufacturer. This is to say that community interest in any industry is first concerned with what an industry contributes to the community; i.e., payrolls. The community also has an indirect interest in profits, however, since failure to earn a profit is certain to destroy the payroll.

The figures given for Item 1 are those for total plant (but not central administrative offices) payrolls. These figures are the ones used as divisors to obtain the values shown in the indented lines.

The figures for Item 2 are the total costs of raw materials, fuel, electricity, containers, and factory supplies, for the United States and the selected individual states; in the indented line, the figures show, for example, that for each $100 of plant wages and salaries, the average plant in the United States processes material and consumes fuel, power, and supplies costing $287; for the average plant in Georgia this figure is $542, the second highest shown.

Item 3 shows the total Value of Product, a figure which would correspond exactly with total sales if every item made in a year

TABLE I

SELECTED CENSUS STATISTICS PER $100 OF PLANT WAGES AND SALARIES FOR PAPERBOARD CONTAINERS AND BOXES (NOT ELSEWHERE CLASSIFIED) IN SOUTHEAST AND SELECTED STATES FOR 1939

	Item	United States	Florida	Georgia	Louisiana	North Carolina	Tennessee	New York	Ohio
1	Wages and Salaries.....	$ 74 555,119	$ 65 986	$ 514.243	$ 663.752	$ 792 834	$ 704,653	$14,472,262	$ 7,000,722
2	Cost of Materials.. ...	213 838,608	469 734	2,789,588	2,675,059	2 393,942	2,137 464	34,939,314	19,889,689
	Per $100 in Wages and Salaries	287	712	542	403	302	303	241	284
3	Value of Product.....	382,709,595	700 499	4,132,939	4,537,551	4,500,404	3,824,535	66,885,977	34,912,792
	Per $100 in Wages and Salaries	513	1,062	804	684	568	543	462	499
4	Value Added	168,870 987	230,765	1,343,351	1,862,492	2,106,462	1,687,071	31,946,663	15,023,103
	Per $100 in Wages and Salaries	227	350	261	281	266	239	221	215
5	Gross Margin	94 315,868	164,779	829,108	1,198,740	1,313,628	982,418	17,474,401	8,022,381
	Per $100 in Wages and Salaries	127	250	161	181	166	139	121	115
6	Salaried Officers*	10,841,974	7,611	106,000	143,293	163,222	122,110	2,873,164	635,430
	Per $100 in Wages and Salaries	15	12	21	22	21	17	20	9
7	Distribution Salaries	9 930,874	7,173	250,404	61,534	87,354	54,523	2,365,895	616,756
	Per $100 in Wages and Salaries	13	11	49	9	11	8	16	9
8	Fuel*	1,511,853	...	18,102	7,640	18,543	20,369	245,908	159,568
	Per $100 in Wages and Salaries	2	...	4	1	2	3	2	2
9	Purchased Elec Energy**	2,013,602	2,160	15,634	16,040	20,664	15,861	420,672	159,174
	Per $100 in Wages and Salaries	3	3	3	2	3	2	3	2

*Included in Gross Margin and in Value Added
**Included in Cost of Materials.

were sold in the same year. The indented line shows that, for example, for each $100 of plant wages and salaries, the average plant in the United States produces products valued at $513; in Georgia, $804.

Item 4 shows the Value Added by Manufacture and is simply the difference between Value of Product (Item 3) and Cost of Material (Item 2). This item is the sum of Wages and Salaries (Item 1) and Gross Margin (Item 5). Figures in the indented line (Item 4) show, for example, that the Value Added by Manufacture to the material, fuel, power, and supplies is $226 for the United States; $261 for Georgia.

The Gross Margin, illustrated by the figures for Item 5, is that part of Value Added (Item 4) which remains after subtracting Wages and Salaries (Item 1) and includes all the current funds available for selling costs, taxes, interest, miscellaneous overhead, management, and, finally, profits. Figures in the indented line show that, for example, the Gross Margin remaining for the average plant in the United States is $126 per $100 of Wages and Salaries; in Georgia, $161. This value is always $100 less than that for Value Added.

CONCLUSIONS

In considering the five aggregates and four values per $100 of Wages and Salaries, as shown for the United States and the seven states selected, the values shown on the four indented lines immediately permit a series of conclusions regarding the manufacture of paper boxes. These are:

1. All the Southeastern states consume a greater value of material and produce a greater Value of Product per $100 of payrolls than either the United States or the two check states, New York and Ohio, the latter two being below the United States average on both items.

2. The Value Added by Manufacture and, of course, the Gross Margin are also higher per $100 of Wages and Salaries for all the Southeastern states, and lower in New York and Ohio than the United States average.

3. The Value of Product in the Southeast is fairly equally divided between Georgia, Louisiana, North Carolina, and Tennessee.

As is apparent from the above summary, the manufacture of paperboard boxes in the Southeast yields a higher Value of Product and Value Added by Manufacture, per $100 of payrolls, and consumes a greater value of material, on the same basis, than similar operations in the North. Incidentally, however, part of this advantage is offset by the production in the Southeast of a lower proportion of the more profitable lithographed set-up boxes.

In the Georgia figures, there is one peculiarity which merits special attention. In Distribution Salaries (Item 7), one of the items not already discussed, the Georgia values per $100 of Wages and Salaries are $49 as compared with $13 for the United States. Neither for the states shown in Table I nor for any other state is as great a difference from the average found. It is probable that, because of Georgia's position as a distribution center, distribution salaries in part attributable to plants under the same ownership but located in some other Southeastern state have been charged to Georgia plants.

Similarly, the Georgia figure for Salaried Officers (Item 6) is $21, while that for the United States is $15. This tends to suggest, since values similar to that for Georgia also occur in Louisiana, North Carolina, and New York (one of the comparison states), that earnings are being distributed in the form of salaries.

Another peculiarity appears in the Georgia column for Fuel (Item 8), where the United States average is $2 (also a typical figure for most of the states), whereas that for Georgia is $4. This might suggest, when considered in connection with the apparently greater efficiency indicated by the relatively high use of material per wage dollar, that some unique use of heat had contributed to this result. On the other hand, the very small values for Fuel shown for all of the other states also suggests that this variation may be the result of some special condition in one or two plants, and, in consequence, may therefore have no particular significance.

USE OF METHOD

Individual plant managements can compare their own accounting figures with averages for their competitors by simply recasting their figures into the form described.

TABLE II

PER CENTS OF VALUE OF PRODUCT OF SELECTED CENSUS STATISTICS FOR PAPERBOARD CONTAINERS AND BOXES

Item	United States	Florida	Georgia	Louisiana	North Carolina	Tennessee	Texas	Virginia	New York	Ohio
Value of Product.....	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Cost of Materials.....	55.87	67.06	67.50	58.95	53.19	55.89	55.36	59.45	52.24	56.97
Value Added	44.13	32.94	32.50	41.05	46.81	44.11	44.64	40.55	47.76	43.03
Wages and Salaries.....	19.48	9.42	12.44	14.63	17.62	18.42	16.63	16.41	21.64	20.05
Gross Margin	24.65	23.52	20.06	26.42	29.19	25.69	28.01	24.14	26.12	22.98
Salaried Officers	2.83	1.09	2.56	3.16	3.63	3.19	1.62	1.33	4.30	1.82
Distribution Salaries	2.59	1.02	6.06	1.36	1.94	1.43	2.63	1.53	3.54	1.77
Total	5.43	2.11	8.62	4.51	5.57	4.62	4.25	2.86	7.84	3.59
Fuel	0.40	...	0.44	0.17	0.41	0.53	0.24	0.37	0.37	0.46
Purchased Elec. Energy....	0.52	0.31	0.38	0.35	0.46	0.41	0.53	0.50	0.63	0.46
Total	0.92	0.31	0.82	0.52	0.87	0.94	0.77	0.87	1.00	0.92

In studying such a table, however, it should be borne in mind that the census figures are essentially averages. Each individual plant will vary in its relationships, some being higher, some being lower.

Values for individual plants per dollar of expenditures for wages and salaries are favorable when they are higher than the average for Cost of Material, Value of Product, Value Added, and Gross Margin. The items below the crossline (Items 6-9 in Table I) will vary with the circumstances. Frequently, variations of considerable amount will suggest advantages or difficulties which should be studied.

The technique described can be applied to many industries, but not to all; for example, the census is forced to combine a very considerable number of important chemical industries under the heading "Chemical Industries, Not Elsewhere Classified." In this case, probably the only common factor is that they all produce chemicals, but the differences in processing and marketing are so great that no valid conclusions may be drawn.

COMPARISON WITH PERCENTAGES

By way of contrast, Table II is also included. This table deals with the same data as Table I, presented as per cents of the Value of Product.

In general, it is true that these percentage figures may usually be expected to yield similar information to that derived by the method previously described. The conclusions drawn, however, are subject to these limitations: first, any abnormality is understated, for the reason that the 100 per cent value is the sum of Cost of Materials and Value Added, rather than a part of Value Added. This means that in the case of percentages based on a total (or Value of Product), any change in the total usually results in small changes in every percentage, while in contrast the series based on Wages and Salaries tends to affect to a greater extent any particular item which is out of line, thus calling attention to either a favorable or unfavorable situation.

For example, the Gross Margin percentage in Table II for Georgia is 20.06 per cent, lowest of all the figures for this item, whereas in Table I the Georgia Gross Margin is second from highest per $100 of Payrolls although both values are based on the same figure. The lower value in Table II reflects the high percentage for Cost of Materials. It can be seen, then, that use of the technique by which Table I was derived makes possible comparisons of less complexity than the more conventional method used in Table II.

Obviously, the usefulness of this technique depends entirely on the clear thinking which is applied to the interpretation of the data, the ability to relate variations from the average for any particular figure with the events which have occurred in the period being examined, and the amount of curiosity employed, remembering that in dealing with averages, "profit is most often above the average."

TVA COMMERCE AND INDUSTRY ACTIVITIES

By JOHN C. SLACK*

The Tennessee Valley Authority is far more than a builder of dams and power plants. Its activities affect many people beyond the reaches of the Tennessee River. For example, one of its departments, the Commerce Department, has long been a sponsor of industrial research in the Southeast. At Georgia Tech, it was joint sponsor for several years of research on the utilization of domestic flax and is now a joint sponsor of Engineering Experiment Station work on the preservation of foods by freezing. Since the TVA is therefore an agency of considerable significance in this region, we have prevailed upon its Commerce Department to describe its functions in two articles, the first of which follows.

The TVA Commerce Department is concerned with TVA's activities in behalf of commerce and industry in the integrated regional development program of the Tennessee Valley. In order to perform its work effectively, the Department itself has four divisions: (1) the River Transportation Division, which seeks to have the Tennessee River utilized as a transportation artery which will serve the region's agriculture and industry to the maximum economically feasible extent; (2) the Agricultural Engineering Development Division, which is working to fill needs of the region for special farm equipment and to bring about wider use of electricity on the farm; (3) the Regional Products Research Division, which conducts and arranges for research on the local processing of farm, forest, and mineral resources; and (4) the Industrial Economics Division, which undertakes through economic studies to assist businessmen in translating the region's raw material resources into consumer goods.

These specialized endeavors are interrelated, of course, because TVA believes that the people of the region can best develop their resources if they view each phase in relation to the others. Properly, the resource development activities do not support a "TVA program"; but, rather, the *Tennessee Valley* program, since state and local agencies and private citizens are working together on behalf of regional development, with TVA, in a degree of coordination that is unique.

The activities of all four divisions will be described in this series, but this first article will be limited to a brief description of the activities of the River Transportation Division and the Industrial Economics Division.

DEVELOPING NAVIGATION ON THE TENNESSEE

The River Transportation Division of the TVA Commerce Department, working to assist the public in realizing the utmost from the Tennessee River development, makes studies of: (1) prospective river traffic, (2) coordination of barge service with the services of other carriers, (3) freight rate problems, (4) public and private river terminals, (5) barge line service and floating equipment, and (6) the extent and serviceability of navigation channels.

PROSPECTIVE TRAFFIC

In its survey of shippers and receivers of freight in 1940, the River Transportation Division, after interviewing approximately 3,700 business firms in 191 communities, concluded that the estimated 2,647,000 tons which could be freighted annually on the river when navigation improvements were completed could be increased by the end of a 15-year developmental period to 7,000,000 tons annually, with savings by then on transportation charges of $9,000,000 a year. River improvement was essentially completed in 1945, during which an estimated 2,163,404 tons were transported. Steady growth in the average length of hauls is reflected in the ton-mile growth from 55,334,000 in the year 1937 to 256,465,000 in 1945.

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TVA investigation of the economy of river shipment of various kinds of freight indicates that most prospective Tennessee River traffic is destined to move between the Southeast and areas in the Midwest served by the Missouri, upper Mississippi, Illinois, and Ohio Rivers, because of the directness of the routes. However, it also appears that traffic between the Southeast and the South and West will increase considerably.

Movement of grain from the Midwest to Tennessee River ports has been more than 100,000 tons a year in recent years, and this volume is expected to expand greatly. Since the development of the river began, new grain storage capacity for 1,125,500 bushels has been erected at waterfront points on the Tennessee. A South Pittsburg, Tennessee, coal tipple, over which a quarter of a million tons of coal a year was transferred during the war, is now used in a peacetime movement of coal to Minneapolis. In this connection, there are indications that a two-way haul will develop—inbound barges loaded with grain will make return trips loaded with coal. One such movement has already demonstrated the possibilities. Another sign of the use being made of the canalized river is the growing number of petroleum products terminals. In just a few years, new tank storage capacity of more than 20,000,000 gallons has been or is being built along the waterfront, where none existed before the development of the river.

COORDINATION OF CARRIERS

River transportation is usually a combination of barge line and railroad or truck service. In fact, according to estimates, two-thirds of the tonnage transported on the inland waterways originates or terminates at off-river points. With this in mind, TVA, other agencies, and people interested in the Tennessee River are working for a coordination of carrier service. They have urged the publication of joint tariffs. Barge-rail and barge-rail-truck joint rates, incidentally, have developed more slowly than barge-truck tariffs.

FREIGHT RATE PROBLEMS

The TVA has studied and reported to the President on Interterritorial Freight Rate Problems and has stimulated and supported public awareness of the barrier to national productiveness that is presented by regionalized railroad freight rates. The United States Supreme Court now is considering an appeal from the Interstate Commerce Commission ruling of May 15, 1945, which was a step toward equalization of class rates, under which most high-grade manufactured goods now move.

RIVER TERMINALS

Recognizing that terminals must be available to attract a large volume of traffic to the river which otherwise would not come, the TVA has made studies of terminal needs and potential locations. One coal and four general-purpose, public-use terminals have been built and operated by TVA. Also, some shippers have enough freight to justify the operation of private terminals, such as those companies which own the grain and oil terminals that have sprung up along the Tennessee. TVA assistance is available to all businessmen who are planning river terminals.

BARGE LINE SERVICE

At the present time, there are about 15 private carriers on the Tennessee who are hauling sand and gravel, grain, clay, and cement. About the same number of for-hire barge lines transport grain, gasoline, forest products, mussel shells, coal, steel products, motor vehicles, and other commodities. Several are common carriers of general freight. TVA supplies shippers and receivers with information regarding barge line service and otherwise assists in bringing about a smooth flow of traffic through studies of barge line service and floating equipment and correspondence and conferences based on them.

NAVIGATION CHANNELS

The TVA study of the extent and serviceability of navigation channels has included a plan for the development of the Tennessee River channel and 630-mile sailing line for a nine-foot navigation and 275 miles of tributary channel for three to nine foot navigation. In addition to the investigations made with water transportation of freight as the primary motive, numerous other studies in this general category have

Continued on Page 21

SOME PROPERTIES OF MATTER AT LOW TEMPERATURES

II. SUPERCONDUCTIVITY OF ALLOYS AND COMPOUNDS[1]

By WALDEMAR T. ZIEGLER*

This is the second in a series of articles on the properties of matter at low temperatures. It summarizes present observations on the occurrence of superconductivity in alloys and compounds.

The phenomenon of superconductivity, wherein the electrical resistance and magnetic permeability of a substance become zero at a finite temperature above absolute zero, has received a great deal of study since its discovery by Kammerlingh Onnes in 1911. As yet, however, there is still no satisfactory theory of superconductivity which permits predictions concerning the occurrence of the phenomenon in any particular substance. Thus, while seventeen of the elements have been shown to exhibit superconductivity at temperatures in the range 0.35° to 9.3° K, it is by no means certain that studies at lower temperatures will not show other elements to be superconductors also. The known superconducting elements are confined, at present, to Groups III-A, IV-A, and V-A and Groups II-B, III-B, and IV-B of the Periodic System.

The phenomenon of superconductivity is not confined to pure metals; it has also been observed in a number of alloys and chemical compounds. The chief purpose of this paper is the summarization of the available information on the studies of superconductivity in binary metal-nonmetal systems and compounds, such as the system columbium-hydrogen and the compound CuS, so that a systematic view of the occurrence of the phenomenon may be obtained.

ALLOYS

The electrical and magnetic properties of superconducting alloys and compounds are, in general, strikingly different from these same properties in pure metal superconductors. Thus, whereas the temperature range for transition from the normal to the superconducting state in a pure metal is usually small (0.1° or less), the transition range for alloys and compounds is often one degree or even greater. Also, in a pure metal maintained at a fixed temperature, the destruction of superconductivity (restoration of resistance) by an externally applied magnetic field occurs at a "critical" strength of the field, while in alloys and compounds, on the other hand, the percentage restoration of electrical resistance does not occur at a critical magnetic field strength but depends markedly upon the strength of the applied magnetic field. Marked hysteresis effects are often observed upon removal of the field. In general, the magnetic field strength required for the restoration of normal electrical resistance in a compound or alloy is considerably greater than that required for the destruction of superconductivity in pure metals. However, electrical and magnetic studies of carefully prepared Au_2Bi and CuS has led Shoenberg[2] to suggest that chemical compounds, if prepared pure, might possibly behave in their electrical and magnetic properties like pure metals instead of alloys.

Extensive surveys of the published data on the superconductivity of metal alloy systems have been made elsewhere.[3,4,5] The general features of these observations may be summarized as follows:

(1) Alloys in which a major component is a superconductor are generally super-

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[1]For the first paper in this series, see W. T. Ziegler, THE RESEARCH ENGINEER, September, 1946, pp. 10-13.

[2]D. Schoenberg, *Superconductivity* (London: Cambridge University Press, 1938), p. 78.

[3]W. Meissner, *Handbuch der Experimental Physik*, Vol. II, Part 2, p. 204 (1935).

[4]D. Shoenberg, *op. cit.*

[5]E. F. Burton, H. Grayson Smith, and J. O. Wilhelm, *Phenomena at the Temperature of Liquid Helium* (New York: Reinhold Publishing Corp., 1940).

TABLE I

OCCURRENCE OF SUPERCONDUCTIVITY IN COMPOUNDS*

Nonmetal / Metal	H	B	C	N	O	Si	P	S	As	Se	Te
Al, 1.14°a											
Sc, —b				ScN (1.4°)c							
Ti, 1.81°		TiB (1.26°)d	TiC 1.1°(?) c, d	TiN 3.2° c, d 1.5° e							
V, 4.3°			VC (1.20°)c	VN 7.3° c							
Cr (1.41°)											
Mn, (1.22°)											
Fe, (0.75°)			Fe_3C (1.28°)d			$FeSi_{0.72}$ (1.30°)d		FeS (1.0°)b FeS_2 (20.4°)a	$FeAs_2$ (1.30°)e		
Co, (1.36°)											
Ni, (0.75°)						$NiSi_{0.72}$ (1.30°)d			NiAs (1.30°)e		NiS (20.4°)e
Cu, (1.05°)					Cu_2O (1.0°)f	Cu_3Si (1.26°)e	Cu_3P (1.05°)b	CuS 1.61° f, i	Cu_3As (1.30°)e, h	Cu_2Se (1.26°)e	CuTe (1.26°)e
Zn, 0.79°											
Ga, 1.07°											
Ge, (0.05°)											
Y, —											
Zr, 0.70°		ZrB 3.05° d	ZrC 3.7° d	ZrN 9.5° d							
Cb, 9.22°	Cb-H 7.3-9.0° g, i	CbB (9.5°)i, j	CbC 10.3° c	CbN 15.3° g, i, m Cb_2N (9.5°)i	CbO (1.4°)i Cb_2O_3 (1.5°)i CbO_2 (1.5°)i						
Mo, (0.3°)r			Mo_2C 2.86° c MoC 7.5° c, i Mo-C 8.4-9.2° n		MoO_2 (1.30°)e Mo_2O_5 (1.3°)e				$MoAs_2$ (1.30°)e		
Ma, —											
Ru, (1.17°)			RuC_x (1.96°)j								
Rh, (1.32°)											
Pd, (1.12°)											
Ag, (0.74°)									Ag-As (1.3°)e	Ag_2Se (20.4°)e	
Cd, 0.54°					CdO (1.3°)e						
In, 3.37°											
Sn, 3.69°					SnO 3.6°(?)e SnO_2 (1.3°)e		Sn-P 5.2° b				
La, 4.71°											
Hf, 0.35°		HfB (1.26°)d	HfC (1.23°)d								
Ta, 4.38°	Ta-H 2.8-4.1° g, i		TaC 9.35° c, d	TaN (1.55°)e, i Ta_2N (1.55°)i		$TaSi_2$ 4.36° d					
W, (0.74°)			W_2C 2.75° c WC 3.4° c		WO_2 (1.1°)e						
Re, (1.36°)											
Os, (1.8°)											
Ir, (1.20°)											
Pt, (0.77°)											
Au, (0.05°)									Au-As (1.9°)i		
Hg, 4.12°								HgS (20.4°)e			
Tl, 2.38°					Tl_2O_3 (1.30°)e						
Pb, 7.26°					PbO_2 (1.3°)e Pb_2O (1.3°)e		Pb-P 7.8° o	PbS 4.3°(?) d, b, f, h	Pb-As 8.4° o	PbSe (1.26°)e	PbTe (1.26°)e
Bi, (0.05°)								Bi_2S_3 (1.3°)e, h		Bi_2Se_3 (1.26°)e	Bi_2Te_3 (1.26°)e
Po, —											
Ac, —											
Th, 1.32°											
Pa, —											
U (0.98°)r											

conductors. Their transition temperatures and transition ranges are functions of the composition of the alloy. Figure 1 shows the results of a study made by Allen[6] of the tin-thallium system which illustrates these facts. This system consists of a eutectic region from 0-73 atom per cent thallium, which latter composition represents the saturation of the homogenous mixed crystal phase that covers the rest of the system to pure thallium.[7]

(2) Binary alloys of lead, tin, and thallium with phosphorous, arsenic, antimony, and bismuth, of the compositions so far studied, generally exhibit superconductivity at a higher temperature than the pure metal superconductor.

(3) Superconductivity has been observed in the binary intermetallic compounds, Au_2Bi and Bi_2Ni, in which none of the pure metal components are superconductors.[8]

COMPOUNDS

The occurrence of superconductivity in compounds is of especial interest. Table I contains a summary of all known superconducting binary systems in which one component is a metal and the other component is a non-metal.[9] In addition, all binary systems in this same category which have been studied and found *not* to be superconductors are shown, so that a systematic view of the occurrence of superconductivity may be obtained. Temperatures (in °K) given in parentheses refer to the fact that the substance in question was studied down to this

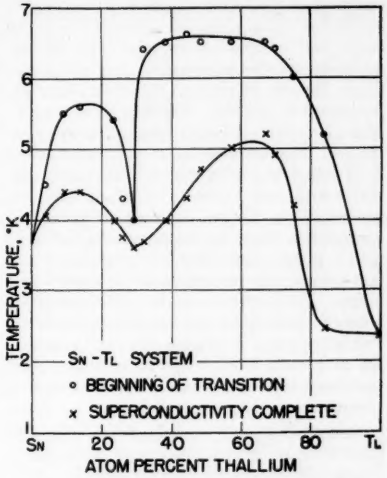

Figure 1. Variation with composition of the superconducting transition temperature of tin-thallium alloys.

[6]J. F. Allen, *Phil. Mag. 16*, 1005 (1933).

[7]P. Fuchs, *Z. Anorg. Chem. 107*, 308 (1919).

[8]Gold and bismuth have been studied down to 0.05°K by N. Kurti and F. Simon, *Proc. Roy. Soc. (London) A151*, 610 (1935); nickel has been studied down to 0.75°K (Ref. 2).

[9]See also summaries given in Refs. 3, 4, and 5.

*A summary of the binary systems and compounds containing a metal and a nonmetal which have been studied for superconductivity to date. No studies of compounds of Li, Na, K, Rb, Cs, Be, Mg, Ca, Sr, Ba, Sb (all nonsuperconducting metals) with these nonmetals have yet been made.

(a) All transition temperatures given for metals are taken from D. Shoenberg, *Superconductivity* (London: Cambridge University Press, 1938), p. 106, unless otherwise noted.

(b) A dash (—) means that the metal has not been investigated to date.

(c) W. Meissner and H. Franz, *Z. Physik 65*, 30 (1930).

(d) W. Meissner, H. Franz and H. Westerhoff, *ibid. 75*, 521 (1932).

(e) W. Meissner, H. Franz and H. Westerhoff, *Ann. Physik 17*, 593 (1933).

(f) W. Meissner, *Z. Physik 58*, 570 (1929).

(g) F. H. Horn, Dissertation, Johns Hopkins University, Baltimore, Md., June, 1941; F. H. Horn, W. F. Brucksch, Jr., W. T. Ziegler, and D. H. Andrews, *Phys. Rev. 61*, 738 (1941); Paper to be published shortly.

(h) J. C. McLennan, J. F. Allen, and J. O. Wilhelm, *Phil. Mag.* (7), *10*, 500 (1930).

(i) W. Meissner and H. Franz, *Naturwissensch 18*, 418 (1930).

(j) J. C. McLennan, J. F. Allen, and J. O. Wilhelm, *Trans. Roy. Soc. Can.*, Sect. III, *25*, 13 (1931).

(k) D. Shoenberg, *Nature 142*, 874 (1938).

(l) G. Aschermann, E. Friederich, E. Justi, and J. Kramer, *Physik. Z. 42*, 349 (1941); *Chem. Absts. 36*, 4745 (1942).

(m) Papers presented before the Division of Physical and Inorganic Chemistry of the American Chemical Society, April 9, 1946, at Atlantic City, N. J., by R. M. Milton and S. J. Socolar, Johns Hopkins University, Baltimore, Md.

(n) W. Meissner, H. Franz, and H. Westerhoff, *Ann. Physik 13*, 505 (1932).

(o) J. C. McLennan, J. F. Allen, and J. O. Wilhelm, *Trans. Roy. Soc. Can.*, Sect. III, *24* (1930).

(p) J. D. Babbit and K. Mendelssohn, *Phil. Mag. 20*, 1025 (1935).

(q) B. Beckham, Leiden Comm., *132g* (1913).

(r) D. Shoenberg, *Proc. Comb. Phil. Soc. 36*, 84 (1940); *Chem. Absts. 34*, 2668 (1940).

temperature and found not to be a superconductor. Temperatures enclosed in black boxes and without parentheses refer to the midpoint of the superconducting transition range for the substance. Where a range of temperatures is given, this implies that samples of several different compositions were studied. The formula of a compound given in Table I is, in most cases, that used by the investigator, reference to whom is given by lower-case letters. In many instances, it is probable that the substance studied was not a pure compound, but was instead a mixture of compounds or even a solid solution. A question mark (?) associated with a particular superconductor implies that doubt was expressed by the investigator as to whether or not superconductivity was due to the compound or to filaments of free metal.

Several interesting relations have emerged from a study of such alloys and compounds. These may be summarized as follows:

(1) The boride, carbide, and nitride of a given metal usually have a progressively higher transition temperature than the pure metal.

(2) A few compounds and metal-nonmetal alloys exhibit superconductivity even though none of the elemental components is a superconductor. Examples of such systems are CuS, W_2C, WC, and the molybdenum-carbon system.

(3) Studies of superconductivity in columbium-hydrogen and tantalum-hydrogen solid solutions have shown that the expansion of the body-centered cubic metal atom lattice, which occurs with increasing atom per cent dissolved hydrogen, is accompanied by a corresponding decrease in transition temperature and increased transition range.[10] Allen[6] has observed a similar effect in Sn-Tl alloys.

(4) In all binary systems and compounds of this type which have been studied to date, the electrical conductivity in the normal state is similar to that which occurs in metals; that is, the electrical conductivity increases with decreasing temperature down to the temperature at which superconductivity sets in.

An examination of the crystal structures (where known) of the substances listed in Table I shows that the structures of a large number of these are quite simple. Thus, the substances TiC, TiN, VN, ZrC, ZrN, CbC, CbN, TaC, and PbS, all of them superconductors with the possible exception of PbS, all have a NaCl-type structure.[11a,b,c] However, the closely related substances, VC, HfC, PbSe, and PbTe, which likewise have NaCl-type structures,[11b,c] are not superconductors at 1.3° K, the lowest temperatures so far used in their study. That a simple structure is not a prerequisite for the occurrence of superconductivity is shown by CuS, which has a complicated structure.[11d]

A very interesting development of the last few years has been the discovery of substances having high superconducting transition temperatures. Thus, columbium nitride, CbN, has been shown[10] to have a transition temperature at about 15° K, while a transition temperature of 23° K has been reported for columbium nitride made from columbium containing 5 per cent tantalum.[12] More recently, Ogg[13] has reported the discovery of superconductivity at temperatures of 70-80° K (and possibly at temperatures as high as 180-190° K) in rings made of rapidly frozen sodium-ammonia solutions.

Much work still remains to be done on the substances listed in Table I, at still lower temperatures and with other compounds and alloy systems, before clear-cut generalizations can be developed which will relate the occurrence of superconductivity to composition, lattice parameters, electronic structure of the component atoms, etc. In all such studies, a careful characterization of the substance by X-ray diffraction and chemical analysis should be made, because of the demonstrated dependence of superconductivity on composition.

[10] F. H. Forn, Dissertation, Johns Hopkins University, Baltimore, Md., June, 1941; F. H. Horn, W. F. Brucksch, Jr., W. T. Ziegler, and D. H. Andrews, *Phys. Rev. 61, 738* (1941); Paper to be published shortly.

[11] *a.* A. E. Van Arkel, *Physica 4*, 286 (1924); *b.* K. Becker and F. Ebert, *Z. f. Physik. Chem. 31*, 268 (1925); *c. Strukturbericht*, Part I. p. 125; *d. Strukturbericht*, Part I. p. 126.

[12] G. Aschermann, E. Friederich, E. Justi, and J. Kramer, *Physik. Z. 42*, 349 (1941).

[13] R. A. Ogg, Jr., *Phys. Rev. 69*, 243 (1946); *ibid., 70*, 93 (1946).

INDUSTRIAL USES OF SPECTROGRAPHIC ANALYSIS

Continued from Page 4

However, this matter of speed is most important in quantitative analysis. One of the large automobile manufacturing companies analyzes its alloy steels quantitatively for chromium, copper, molybdenum, nickel, and silicon in only eight minutes from the time the sample is removed from the furnace. Recently, there has appeared an instrument similar to a spectrograph except that it has photoelectric cells to replace photographic film. With this instrument, called a quantometer, an experienced operator can analyze a sample quantitatively for eleven elements in only forty-five seconds. However, such an instrument lacks flexibility; the eleven elements must always be the same ones and must be present within definite limits. The trouble and expense involved in thus reducing an analysis time from eight minutes to forty-five seconds might appear uneconomical in view of the initial cost of the instrument (approximately $6,500), but in the manufacture of alloys it is highly important to know the composition of the melt in the furnace as soon as possible so that, if it is correct, the melt may be poured immediately, or, if it is incorrect, it may be rectified before further changes have had time to occur.

Of course, a saving of time is important in itself, especially in a period such as this when salaries are high and manpower is short. For many analytical purposes, a spectrograph with two operators can replace ten analysts. Thus the spectrograph, by replacing eight men, soon pays for itself.

6. The spectrographic method does not require large samples, and practically none of the sample is consumed in the analysis. Without the spectrograph, the composition of many archaeological specimens could not have been obtained without materially disfiguring the object in order to obtain samples for ordinary chemical analysis.

7. Finally, by spectrographic methods one can determine the distribution of elements in any or all parts of a substance, while by chemical methods, since a large sample is needed, only the average composition is obtainable.

OTHER USES

Before discussing the foundation and methods of spectrographic analysis, a few other examples of its wide usefulness may be of interest.

The spectrograph has proved invaluable in locating the cause of obscure, nonparasitic diseases in plants and animals. The cattle disease sometimes called "teart" has been shown to be caused by a slight excess of molybdenum in certain grasses, while another cattle disease called "bush sickness" is due to a deficiency of cobalt. In both of these cases, the amounts of the offending metals are so small that ordinary analytical methods would have proved inadequate.

In recent years, spectrographic investigations have shown the great importance of minute quantities of certain elements for the healthy growth of various plants. Fertilizer manufacturers are now almost as much concerned with these "trace elements" as with the three major ones, nitrogen, potassium, and phosphorus.

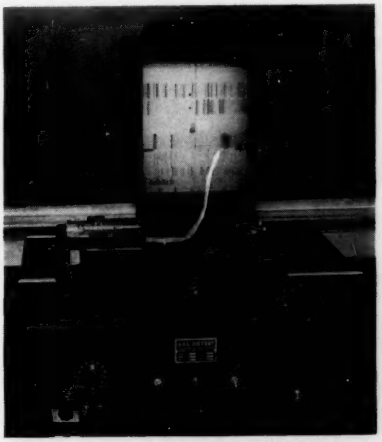

Figure 3. The comparator-densimeter. In this instrument, the elements present in the spectra are identified and their relative amounts determined.

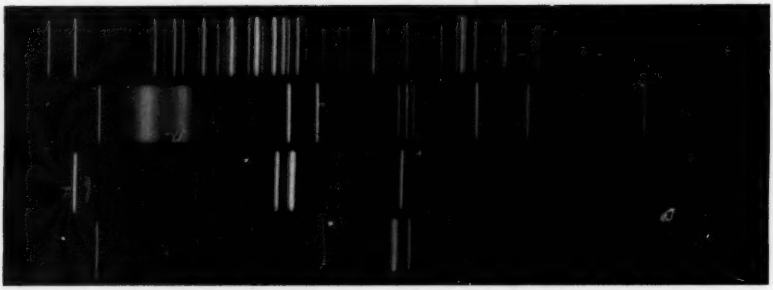

Figure 4. Portions of the spectra of iron, a copper-aluminum alloy, silver, and bismuth (from top to bottom). As may be seen, the spectra of the elements differ considerably, thus making them identifiable by spectrographic analysis.

METHODS

The steps involved in spectrographically performing a qualitative analysis (i.e., an analysis whose objective is the determination of the elements present in the sample but not, as in the case of quantitative analysis, the relative amounts of these elements) are:

1. The preparation of the sample.
2. The excitation of the sample so that light is emitted (Figure 1).
3. The photographing of the resulting light after its passage through the spectrograph, also shown in Figure 1.
4. The interpretation of the resulting photograph, as shown in Figure 3.

A quantitative analysis involves not only the application of these four steps to the unknown sample but also their application to a set of standard samples, for comparison. Thus, quantitative analyses are much longer and more exacting than the qualitative ones.

In general, metallic samples need no preparation and may be used directly as the electrodes—the poles between which an electric arc is struck (assuming, of course, that the size and shape of the samples are satisfactory). Low-melting alloys or metals, such as tin and lead, cannot be used in this way, since they would quickly melt, but such samples may be handled by placing a small piece on the hollowed end of a carbon electrode. If the sample is metallic but in the form of a powder, this can be compacted in a press to a rod and used as described above.

However, if the sample is a nonconductor of electricity (for example, rock or soil), it cannot be used directly as an electrode. Here, however, it is necessary only to grind it to a fine powder and to mix this thoroughly with some powdered carbon, then proceed as above. The carbon, being a good conductor, allows the arc to be struck, and as it burns away, the sample is carried into the arc.

If the sample submitted for analysis is a solution, this is evaporated and the residue analyzed.

As mentioned, an electric arc or spark is used to excite the sample to the point where light is evolved. At the high temperature thus produced (about 6000° C.), most compounds are decomposed into their elements, and these elements then emit light of characteristic wave lengths (colors). The fundamental basis of spectrographic analysis, of course, is the previously mentioned fact that each element, when thus excited, emits light which is characteristic of itself and which differs from that emitted by any other element.

The light from the arc is passed through a narrow slit (about one thousandth of an inch) into the spectrograph, where it is broken into its component wave length; i.e., a spectrum is formed. There are two main types of spectrographs; in one, the spectrum is formed by passing light through a prism of glass or quartz, while in the other it is produced by reflecting light from a grating. These gratings usually consist of a small metal plate, on one side of

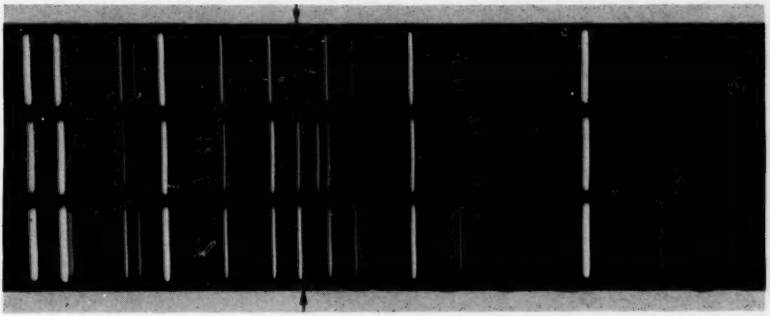

Figure 5. Spectrograms of three samples of steel containing different percentages of copper. The lower specimen contains 0.21%, the middle one 0.09%, and the upper one only 0.025% of copper. Notice the decrease in intensity of the indicated copper line.

which many fine parallel lines are scratched; one of these gratings at Georgia Tech has 24,400 lines per inch.

The spectrum is photographed either on a glass plate or on a film. The developing, fixing, and drying is done in the usual way, but the temperature is carefully controlled.

As an aid in the interpretation of the photograph of a spectrum (a spectrogram), a comparator-densitometer is used. With this instrument, shown in Figure 3, one can not only determine the wave length of a given line, and thus decide to what element it belongs, but can also measure the density (blackness) of the line and in this way determine the percentage of the element present.

SPECTROSCOPY AT GEORGIA TECH

Through the combined generosity of the General Education Board of the Rockefeller Foundation and the State Board of Regents, Georgia Tech in recent years has been able to obtain much fine research equipment. The major portion of the funds allotted to the Chemistry Department has been spent in equipping its spectrographic laboratory, at a cost of approximately $14,000.

The wide usefulness of such spectrographic equipment is indicated by two research projects now being conducted in this laboratory. The first, of a purely fundamental nature, is concerned with the decomposition of ozone in solution (under the direction of Dr. William H. Eberhardt), while the second, of a more applied character, is an investigation of a method for the quantitative determination of iron and titanium in kaolins.

Spectrographic analysis is of importance to many industries, both for production control and for research. Its continued use in scientific investigations will aid in the solution of many problems and will add to our store of fundamental and applied knowledge.

TVA ACTIVITIES

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been prepared; for example, one on the usefulness of the slack-water lakes for recreational navigation. There are now some 40 public boat docks along the main thread of the Tennessee and numerous others on tributary lakes.

INDUSTRIAL ECONOMIC ACTIVITIES

The active efforts of the Tennessee Valley's businessmen are vital to the region's drive toward effective development of its many resources. Efficiency in this role is determined, to an extent, by the accessibility to the entrepreneur of usable industrial economic information, and its application to his particular problem. Within the TVA

framework, the Industrial Economics Division is the focal point for meeting the need this represents, through the medium of industrial economic analysis.

Three types of economic analyses have been made: (1) analyses of broad economic trends and changes which affect the development of the Valley; one such study is now in progress; (2) analyses of specific processing industries; in this category is a comprehensive study of the frozen food industry; (3) analyses of proposed individual enterprises. These later studies present data to businessmen for use in determining the economic feasibility of a given enterprise at a specific location at a particular time. About 500 industrial economic inquiries were answered in the past two years, and the monthly rate of inquiries received is constantly increasing.

No effort is made, through these analyses, to impose predetermined plans on businessmen. Instead, they are designed to help businessmen make decisions from logical alternatives. While appraising the factors contributing to economic practicability, these analyses do not include specific recommendations of plant sites, methods of finance, etc.

In general, they show: (1) the possible effects on the natural resources of the Valley; (2) the extent to which the goods and services which these enterprises produce will satisfy the wants of the people; (3) the economic returns that may be expected by capital, management, and labor by engaging in the new enterprise; and (4) the relative economic opportunities in enterprises.

Analyses are prepared in cooperation with the staffs of other divisions and departments within the TVA, and also through cooperative agreements with the staffs of state planning commissions and universities of the Valley states. Many industrial economic studies are initiated and carried through with the cooperation of the businessmen who are directly concerned and the local officials and leaders who are also interested. This collaborative effort makes possible a unique integration of technical and economic data with local information which has a direct bearing upon the success of an enterprise.

These reports are in constant demand and are made available to inquirers through cooperative relationships with public agencies and institutions; they are further augmented, as the need develops, by information and data collected and analyzed by the Industrial Economics Division. In this way, economic research serves the need of the region's businessmen effectively and directly.

NEW POTTERY PLANT

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test each design, in order to determine inherent faults which might make manufacture difficult.

ESTABLISHMENT OF THE PLANT

The critical shortage of manufacturing sites necessitated the building of an entirely new plant. Many regions were considered, but the general area of Atlanta was preferred, for purposes of distribution. Since practically no trained labor existed, this item did not enter into the selection of a plant site.

The determining factor in final choice was the Marietta Industrial Association, a civic-minded group of that city whose purpose is to encourage diversification of industry in Cobb County. Under a plan worked out by this group, a building was erected and rented, with option to buy, to the newly organized company. Because of critical shortages of building materials, prefabricated aluminum buildings were selected and arranged in one building.

PROCESSES AND EQUIPMENT

The major piece of equipment is a 31-foot, gas-fired continuous kiln, constructed by the Allied Engineering Company of Cleveland, Ohio. The cross-section of the

space provided for the ware is 13½" x 22", and the cars are 42" long. The kiln contains nine cars, and four extra cars are provided for loading and unloading; approximately 70 cubic feet of ware per day will be produced.

Most production is made by the casting method. The dry ingredients are blunged (agitated) with water to a creamy consistency in an agitator, then screened. This "slip" is then poured into a plaster mold and allowed to stand until the desired wall thickness has been developed; the wall results from the adsorption of water from the slip by the mold. This is a gradual process and requires from 15 to 30 minutes. When the desired wall has formed, the remaining fluid slip is poured out, thus giving hollow ware without the use of cores. After remaining in the mold for another period of 30 to 45 minutes, the ware is set sufficiently to be removed. Preliminary removal of waste is made at this time, and the piece is dried under artificial heat. The ware is further trimmed and sponged to remove mold marks, then sent to the spray booth.

At this point, a thin coating of fine, glass-forming powder is sprayed on the ware. This adheres sufficiently to permit careful handling, so that the piece may then be set on the kiln car. Layers are built up on the car by using posts and refractory slabs. The car is then transferred to the firing track and is fed into the kiln by a continuous screw pusher, whose speed may be altered to suit the ware.

Temperatures are controlled automatically within the kiln by a sensitive pyrometer. Ceramic cones are frequently placed on cars to check the true thermal history of the ware and to insure absolute uniformity of production. As the car emerges from the cooling zone of the furnace, it is allowed to stand in a vestibule to reduce strains. The car is then transferred to the return tracks and unloaded, whereupon it is ready for another cycle.

Additional equipment has been provided to produce ware by the jiggering method. In this case, the dry body ingredients are blended in a Simpson Intension Mixer for one-half hour; sufficient water is added to produce a plastic mix of a "dough" consistency. This plastic mix is fed to a pug mill, which consists of a "U" shaped trough. A shaft carrying flat knives kneads the clay and works it toward the discharge end. Immediately before discharge, the mass is subjected to a vacuum of 24-28 inches of mercury to remove entrapped air, which might cause defects.

A plaster mold is placed on a revolving vertical spindle, and a ball of the mix is thrown on the center of the mold, whereupon a pivoted template is brought down, spreading the ball and giving form to the top side of the object. The plaster mold itself provides the shape for the underside of the piece. The mold and newly formed piece are set aside for drying, and the ensuing shrinkage releases the ware from the mold. Following this stage, the process is identical with the casting method.

OBJECTIVES OF THE COMPANY

The newly formed company, known as Design, Inc., specializes in flower containers, ceramic sculpture, and figurines. Production of a modern design dinnerware is contemplated for the near future. At present, 17 persons are employed, and this number will eventually be expanded to 30.

In this manner, Georgia raw materials will be used to produce quality products in Georgia, for sale to Georgia markets.

PATENTS AND INDUSTRY

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While on the subject of patent fallacies, it might be of interest to note that the marking "Patent Pending" does not protect the manufacturer who is producing and selling an article while his patent is still being prosecuted through the Patent Office. All it does is "to notify the public that at some future date a patent *may* issue which may give the owner the right to prevent the public from *further* manufacture, use, or sale of certain features of the article so marked. It is true that after a patent issues, the owner has the right to proceed against those who are still using the now-patented device. And if these users are customers of a responsible manufacturer, the manufacturer may undertake to reimburse the patent owner for any damage he may suffer by reason of contin-

ued use of the patented article by the (non-owner) manufacturer's customers."[1]

PATENT REQUIREMENTS

Having put the cart before the horse by describing what the ownership of a patent will not permit, it might be well to consider, briefly, the requirements for and steps to be followed in obtaining these grants which, despite their limitations, are of vital importance for every company so long as its competitors continue to acquire them.

The law provides that "any person who has invented or discovered any new or useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof, or who has invented or discovered and asexually reproduced any distinct and new variety of plant, other than a tuber-propagated plant, not known or used by others in this country, before his invention or discovery thereof, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, or more than one year prior to his application, and not in public use or on sale in this country for more than one year prior to his application, unless the same is proved to have been abandoned, may, upon payment of the fees required by law, and other due proceeding had, obtain a patent therefor."

Assuming for a moment that these conditions exist for a given invention, insofar as the inventor can tell, what are the steps which he should take to acquire patent protection?

A detailed discussion of these must be left to a later article, but in brief the inventor should: (1) make certain that his records are in good order and that a "record of invention" (description of the "why" and "how" of the invention) has been prepared and witnessed, (2) engage a reputable patent attorney to make a "novelty search" of the literature (including patents), and (3) if this search fails to indicate that the invention has been patented, apply for a patent, again making use of a reliable patent attorney.

If patents, when obtained, are to be valid, careful attention must be given at all stages of inventive development to the keeping of adequate, authenticated records. Also, when an invention is actually achieved, a complete description of it should likewise be prepared and witnessed.

Future articles in this series will deal in more detail with the keeping of research records, preparation of the "record of invention," patent searching, patent application preparation and patent prosecution.

In the words of the National Patent Planning Commission, "the American patent system * * * has accomplished all that the framers of the Constitution intended. It is the only provision of the government (save for the present research program) for the promotion of invention and discovery and is the basis upon which our entire industrial civilization rests.

"The American people and their Government should recognize the fundamental rightness and fairness of protecting the creations of its inventors by the patent grant. The basic principles of the present system should be preserved. The system has contributed to the growth and greatness of our nation; it has:

(1) Encouraged and rewarded inventiveness and creativeness, producing new products and processes which have placed the United States far ahead of other countries in the field of scientific and technological endeavor;

(2) Stimulated American inventors to originate a major portion of the important industrial and basic inventions of the past 150 years;

(3) Facilitated the rapid development and general application of new discoveries in the United States to an extent exceeding that of any other country;

(4) Contributed to the achievement of the highest standard of living that any nation has ever enjoyed;

(5) Stimulated creation and development of products and processes necessary to arm the nation and to wage successful war;

(6) Contributed to the improvement of the public health and the public safety; and

(7) Operated to protect the individual and small business concerns during the formative period of a new enterprise.

"The strongest industrial nations have the most effective patent systems, and after a careful study, the Commission has reached the conclusion that the American system is the best in the world."